

(19)



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Office européen des brevets



(11)

EP 0 738 888 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
07.11.2001 Bulletin 2001/45

(51) Int Cl.7: **G01N 33/08**, G01N 29/04,
A01K 43/00

(21) Application number: **96201027.8**

(22) Date of filing: **17.04.1996**

(54) Probe, device and method for testing eggs

Prüfkopf, Vorrichtung und Verfahren zum Testen von Eiern

Tête de soudage, appareil et méthode pour tester des oeufs

(84) Designated Contracting States:
DE ES FR GB IT NL

(30) Priority: **19.04.1995 NL 1000177**

(43) Date of publication of application:
23.10.1996 Bulletin 1996/43

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Descripti n

[0001] The invention relates to a probe as described in the preamb l of claim 1. Such a probe is known from European patent specification 0.602.285.

[0002] For testing an egg for th presence of cracks, ruptures or other defects, it is known to excite that egg with a pulse-shaped mechanical point load, whereby the eggshell is set vibrating. The vibration characteristic of the eggshell is indicative of the presence of a defect within a predetermined distance relative to the excitation position. In the above-mentioned publication, the excitation is effected by an excitation member which is suspended by means of a diaphragm at an end of a tube. Mounted at the other end of the tube is a microphone for receiving sound waves in the tube caused by the excitation member. In this known device, the excitation member is a spherical body. The tube is axially displaceable to enable the excitation member to be brought into contact with an egg to be examined. The displacement of that tube takes place by means of a stepping motor which, via two drive wheels, engages a drive rod attached to that tube.

[0003] Although this construction is in itself satisfactory, there are nevertheless some problems attached to it.

[0004] An important problem relates to the attachment of the spherical excitation member by means of a diaphragm in the tube. Such an attachment is quite difficult to manufacture. Attaching by means of glueing is a complicated procedure, and the necessity of using glue is experienced as undesired.

[0005] A further important problem concerns the relatively short life of the diaphragm.

[0006] Further, it has proved to be rather difficult to give the probe reproducible characteristics, while it is in particular difficult to bring the thickness of the diaphragm to the proper value. This is a drawback, on the one hand because, in practice, a large number of such probes will be used in a testing apparatus, and on the other hand because after replacement of a specific specimen by another specimen, the response of the new specimen is not simply comparable with the old specimen. In practice, the replacement of specimens is an operation which occurs relatively often, because the device is easily fouled by broken eggs, which necessitates cleaning.

[0007] In itself, the cleaning of the individual devices is a problem as well, precisely because of the attachment of the excitation member by means of a diaphragm.

[0008] A further problem of the known construction concerns the attachment of the microphone to the top end of the tube. In the first place, this has as a consequence that th weight of the moving parts of the known construction is relatively great. In the second place, it is a problem to transmit the signals from the moving microphone to a signal-processing device: it is true that for this purpose it is possible to utilize an electrically con-

ductive wire which is free over some distance thereof, enabling it to follow the reciprocation of the microphone, but that wire may nevertheless impede the movement of the probe, while during the exchange of prob s (for instance for cleaning purposes), having to detach the wire and attach it again is troublesome. In the third place, it is possible that the microphone attached to the tube does not only receive the sound waves caused by the excitation member, but also vibrations of the tube itself, which is undesired.

[0009] In this connection, it also matters that the drive by means of a motor may introduce undesired vibrations. Via the drive rod, those vibrations will be transmitted almost directly to the microphone. A further drawback of the known drive is that the use of a motor requires quite some space and a relatively complicated control, and is relatively expensive.

[0010] A general object of the present invention is to provide improved equipment for testing eggs.

[0011] An important object of the present invention is to solve the above-mentioned problems.

[0012] In accordance with an important aspect of the present invention, a probe has the characteristics as described in the characterizing part of claim 1. Preferred details are mentioned in claims 2-5.

[0013] Because the excitation body is contactlessly suspended in the tube by means of a magnetic field, with a narrow air gap between the inner wall of the tube and the excitation body, a particularly good reproducibility is realized with relatively simple means. Removal and repositing of the excitation body, for instance for cleaning purposes, can be performed in a very simple manner by means of an implement which is magnetic itself, such as for instance a permanent magnet held in hand.

[0014] It is possible that the magnetic field is provided by a magnet coil. However, it is preferred to use a permanent magnet therefor, because it contributes to the reproducibility.

[0015] It is conceivable that the excitation body is manufactured from a permanent magnet. However, it is preferred that the permanent magnet be fixedly disposed adjacent the end of the tube, and that the excitation body be manufactured from a magnetically attractable and preferably stainless material. A shape which offers good results is a spherical excitation body. Some permanent magnets of a suitable shape can be disposed along the circumference of the tube. Preferably, an annular magnet is utilized.

[0016] The combination of an annular magnet and a stainless steel spherical excitation body is also preferred because they are manufactured as standard articles with good reproducibility and are commercially available.

[0017] In accordance with another aspect of the present invention, the microphone is fixedly disposed, i. e. free of the moving tubular probe body.

[0018] In accordance with a further aspect of the present invention, for establishing the reciprocation of

the probe body, a switchable electromagnet is utilized, so that no motor drive is required.

[0019] These and other aspects, characteristics and advantages of the present invention will be explained by the following description of a preferred embodiment of an egg-testing device according to the invention, with reference to the accompanying drawings, wherein:

Fig. 1 shows a longitudinal section of an egg-testing device with a probe according to the invention;

Fig. 2 is a bottom view of the egg-testing device of Fig. 1, with a probe taken away;

Fig. 3 is a diagrammatic view in the longitudinal direction of a roller conveyor of an egg-testing device;

Fig. 4 is a diagrammatic side elevational view of an egg-testing device, with a block diagram of the control thereof; and

Figs. 5A and 5B illustrate the signal processing according to the invention.

[0020] In Fig. 1, an egg-testing device is generally designated by reference numeral 1. The egg-testing device 1 comprises a housing 10 intended to be fixedly mounted on a subframe 101 of an egg-testing device, as will be discussed hereinafter.

[0021] The housing 10 comprises a tube 11 of a magnetizable material, such as ferromagnetic stainless steel or nickel-plated steel. Attached to the tube 11 at a first end thereof is a fastening flange 12 serving for attachment to the subframe. The fastening flange 12 is advantageously made from synthetic material. Attached at the other end of the tube 11 is a second flange 13, which is also advantageously made from synthetic material. Between the two flanges 12 and 13, a bobbin 14 is wound on the tube 11. The bobbin 14 can be formed by several windings of a single wire, whose ends 15 and 16 are designed for external connection.

[0022] In the tube 11, a probe 30 is disposed. The probe 30 comprises a hollow, tubular probe body 31, hereinafter referred to as probe tube, having an outside contour which is adapted to the inside contour of the tube 11 but which has slightly smaller cross dimensions, so that the probe tube 31 is axially freely movable in the tube 11. The axial length of the probe tube 31 is greater than the axial length of the tube 11, with the difference between the axial length of the probe tube 31 and the axial length of the tube 11 defining a free stroke for the probe tube 31.

[0023] Advantageously, the tube 11 has a circular cross section, just as the probe tube 31, as appears more clearly from Fig. 2. In this Fig. 2, wherein the probe tube 31 is left out, it is also clearly visible that the second flange 13 may comprise a number of guide projections 17 (in the example shown: three), projecting radially inwards from the inner wall of the tube 11 to prevent the probe tube 31 from touching the inner wall of the tube 11. Comparable guide projections 18 may be formed on the fastening flange 12.

[0024] During operation, the probe tube 31 is coaxially disposed within the tube 11, their common center line 2 being substantially vertically oriented. At a bottom end 32 of the probe tube 31, a probe flange 33 is formed on the probe tube 31, in which flange an annular, axially polarized magnet 34 is mounted, for instance through glueing or clamping it in an annular groove in the probe flange 33. Such annular magnets are commercially available with a proper reproducibility. Preferably, the annular magnet 34 has its north pole directed towards the tube 11, for a reason that will be explained later on. [0025] Advantageously, the probe tube 31 and the probe flange are manufactured as one whole from plastic.

[0026] Mounted at the top end 35 of the probe tube 31 is a stop flange 36. This stop flange 36 is preferably formed by a second annular magnet, while from a viewpoint of manufacture it is advantageous if the second annular magnet 36 is identical to the first annular magnet 34. In the example shown, the attachment of the second annular magnet 36 to the probe tube 31 is effected by means of a metal coupling bush 37, fixed to the top end 35 of the probe tube 31 by means of, for instance, glueing. The metal coupling bush 37 has an outside diameter which is only slightly less than the inside diameter of the second annular magnet 36, so that the second annular magnet 36 fits around the metal coupling bush 37. In that position, the second annular magnet 36 is magnetically attracted by the metal coupling bush 37 and held in position, and the attractive force exerted is sufficient to enable a reliable use. On the other hand, the second annular magnet 36 acting as stop flange can readily be manually removed from the probe tube 31 through exertion of a pulling force which overcomes the above-mentioned attractive force.

[0027] Provided at the bottom end 32 of the probe tube 31 is a magnetically attractable excitation body 50. In the example shown, the magnetically attractable excitation body 50 is spherical, and it is manufactured from a stainless steel or nickel-plated steel. A diameter that was found suitable for the excitation body 50 is about 9 mm.

[0028] Alternatively, the excitation body 50 may have a cylindrical shape, whilst the bottom end may taper off and have a rounded tip. However, the use of the spherical shape illustrated is preferred, because during excitation, a cylindrical excitation body could tilt and then touch the inside of the tube 11 in an undefined manner, which is disadvantageous to the sound signal generated. The main aspect is that the excitation body 50 is contactlessly suspended within the probe tube 31 by a magnetic field, and is free to vibrate in the direction of the center line 2 of the probe tube 31, i.e. vertically. For that purpose, at least adjacent the bottom end 32, the diameter of the probe tube 31 is slightly greater than the diameter of the excitation body 50. A value that was found suitable for the width of the gap between the excitation body 50 and the inner wall of the probe tube 31 is 0.1 -

0.2 mm.

[0029] The probe tube 31 need not have a greater diameter than the excitation body 50 throughout its length. In the embodiment shown, the probe tube 31 generally has an inside diameter smaller than the diameter of the excitation body 50, and only from the bottom end 32 of the probe tube 31, a vibration chamber 38 for the excitation body 50 is defined by a probe tube portion of a greater diameter. The height of the vibration chamber 38 can be of the order of the diameter of the spherical excitation body 50. If the excitation member 50 has a shape other than spherical, for instance a cylindrical shape, then the height of the vibration chamber 38 should be selected so that the excitation member 50 can be withdrawn into the probe tube 31 as a whole.

[0030] Fig. 1 shows the egg-testing device 1 in a rest state, wherein the probe tube 31 is retracted into the housing 10 and the probe 30 is in its highest position, with the probe flange 33 abutting against the second flange 13. In this highest position, the probe 30 is retained through the attractive force between the annular magnet 34 and the tube 11. The bobbin 14 is currentless.

[0031] When the egg-testing device 1 is to be used for testing an egg, a current pulse (or voltage pulse) of a first polarity is supplied, which first polarity is such that the magnetic field generated by the bobbin 14 exerts a repulsive force on the annular magnet 34. In the example mentioned, the first polarity is such that the bobbin 14 acquires a north pole directed towards the annular magnet 34. The downwardly directed force exerted on the probe 30 by the magnetic field generated should be sufficiently great to overcome the attractive force between the annular magnet 34 and the tube 11. Under the influence of gravitational force, the probe 30 then falls down further.

[0032] If no egg is located under the egg-testing device 1, the probe 30 will reach a lowest position wherein the stop flange 36 abuts against a top face of the fastening flange 12.

[0033] The probe 30 can be returned by re-exciting the bobbin 14 with a current pulse (or voltage pulse) of a second polarity, whereby an upwardly directed force is exerted on the probe 30. For this, a magnetic field generated by the bobbin 14 can be utilized, which magnetic field exerts an attracting force on the annular magnet 34, which force should be sufficiently great to overcome the gravitational force on the probe 30. However, because of the relatively large distance between the bobbin 14 and the annular magnet 34 in the lowest position of the probe 30, the current strength then required is rather great. Therefore, it is preferred that the stop flange 36 is a second, axially polarized annular magnet. The returning of the probe 30 can then be carried out because the magnetic field generated by the bobbin 14 exerts a repulsive force on the second annular magnet 36, which is then located at a relatively short distance from the bobbin 14.

[0034] If the second annular magnet 36 is oriented in the same manner as the first annular magnet 34, i.e. with the north pole facing upwards, then the second polarity should be equal to the first polarity. It is true that in that case, when the bobbin 14 is excited with the second pulse, the first annular magnet 34 is repulsed as well, but in the lowest position of the probe 30 the distance from the bobbin 14 to the first annular magnet 34 is greater than the distance from the bobbin 14 to the second annular magnet 36. However, this is not guaranteed under all circumstances. When large eggs are tested, it will even be a rule that in the position of the probe 30 wherein the excitation body 50 touches the egg, the distance from the bobbin 14 to the first annular magnet 34 is less than the distance from the bobbin 14 to the second annular magnet 36. Hence, it is preferred to have the orientation of the second annular magnet 36 be opposite to that of the first annular magnet 34, i.e. with the north pole facing downwards in the example mentioned. The second polarity should then be opposite to the first polarity. In that case, an upwardly directed force is exerted on the two annular magnets 34 and 36, so that the two magnets cooperate to bring the probe 30 back into its rest position again, regardless of the distance through which the probe 30 has been displaced from its rest position.

[0035] An additional advantage is then that upon excitation with the first polarity, the two annular magnets 34 cooperate to move the probe downwards, as an addition to the gravitational force, and the downwardly directed force experienced by the probe 30 increases according as the second annular magnet 36 approaches the bobbin 14 and the tube 11, so that also in the case where small eggs are tested, the "travel time" of the probe 30 can be relatively short.

[0036] when the probe 30 reaches its rest position, the probe flange 33 contacts the second flange 13. In order to reduce the blow occurring therewith, a shock buffer may be provided in the second flange 13, for instance, and as illustrated, in the form of an O-ring 19.

[0037] If an egg is indeed located under the downwards falling probe 30, the excitation body 50 will be arrested by that egg. The probe tube 31 is then also arrested by the magnetic attractive force between the annular magnet 34 and the excitation body 50. The interaction between the egg and the excitation body 50 can be described as a "collision", whereby the eggshell will slightly deform. The eggshell will make a vibrating movement, comparable with, the movement of a drum-head, and will touch the excitation body 50 several times, which can be described as a "bouncing" of the excitation body 50. As a result, the excitation member 50 will carry out a vibrating movement, whereby sound vibrations are caused in an air column 20 in the tube 11, above the excitation body 50. These sound vibrations will be propagated upwards in that air column 20 and reach a microphone 40 arranged at the top end of that air column 20.

[0038] Owing to the above-mentioned smaller diameter of the top portion of the probe tube 31, the vertical positional freedom of the excitation body 50 is limited. In particular, the excitation body 50 is prevented from touching the microphone 40.

[0039] In accordance with an important aspect of the present invention, the microphone 40 in the preferred exemplary embodiment illustrated is not attached to the probe tube 31 but is fixed relative to the subframe 101. In the embodiment shown, this is realized because the housing 10 comprises a cap 21 in the form of an inverted cup, having a cap flange 22 and a bottom 23. The cap flange 22 is mounted on the subframe 101 mentioned, opposite the fastening flange 12. Attached to the bottom 23 of the cap 21 is a vertically downwardly extending support 24 in the form of a hollow bar, whose outside contour preferably corresponds with the inside contour of the probe tube 31. The microphone 40 is attached to the bottom end of that support 24 in any suitable manner, for instance through glueing or clamping. Connecting wires 41, 42 of the microphone 40 extend upwards through the hollow support 24 and can be connected to a data-processing device, as will be understood.

[0040] It will be understood that owing to this construction, neither the microphone 40 nor the connecting wires 41, 42 thereof will impede the reciprocation of the probe 30.

[0041] The axial length of the cap 21 is such that the stop flange 36 in the rest state illustrated in Fig. 1 remains clear of the bottom 23. Preferably, attached to the cap 21 is a proximity sensor 43 for detecting the probe 30 in its top position or rest position. In the embodiment shown, wherein, in the rest state illustrated in Fig. 1, the stop flange 36 is located very close to the bottom 23 of the cap 21, that proximity sensor 43 is provided in a recess 25 in that bottom 23. Advantageously, the proximity sensor 43 is a Hall sensor, reacting to the second annular magnet 36. Because commercially available Hall sensors are designed so as to be primarily sensitive to the proximity of a south pole, the second annular magnet 36 preferably has its south pole facing upwards.

[0042] Via connecting wires 44, the sensor 43 is connected to a control device, not shown, and enables that control device to recognize error situations in time. A first possible error situation occurs when, for whatever reason, the probe 30 does not leave its top position or rest position in response to the bobbin 14 being provided with a current pulse of the first polarity. This error situation is indicated by the sensor 43 to the control device by a signal representative of the proximity of the second annular magnet 36. A second error situation occurs when, for whatever reason, the probe 30 does not regain its top position or rest position in response to the bobbin 14 being provided with a current pulse of the second polarity. This error situation is indicated by the sensor 43 to the control device by a signal representative of the absence of the second annular magnet 36.

[0043] As has already been observed, the probe 30

can easily be removed. In that case, the second annular magnet 36 stays behind inside the cap 21, and the second annular magnet 36 will be attracted by the tube 11 and will be retained in that position until the probe 30 or a replacing probe 30 is inserted again. The second annular magnet 36 will automatically resume its proper position on the top end 35 of the probe tube 31. Although the retaining force of the tube 11 is generally sufficient, it is in principle conceivable that the second annular magnet 36 shifts when the probe 30 is taken out, and tilts when the probe 30 is reinserted, so that the second annular magnet 36 will then end up upside down. In order to eliminate this possibility, the axial length of the support 24 is preferably such that the microphone 40 is located at or below the level of the fastening flange 12.

[0044] The precise shape of the sound signal received by the microphone 40 depends inter alia on the force with which the excitation body 50 collides with the eggshell. As it is, the egg-testing device 1 is intended to be used in a testing apparatus through which eggs are passed while lying on a conveyor belt or roller conveyor. In general, the eggs lying on that conveyor have a diameter in the range of 34-52 mm, with smaller eggs lying lower in their holders than larger eggs. This means that when a small egg is tested, the distance which the excitation body 50 should travel, while falling, to reach the eggshell is about 24 mm larger than when a large egg is to be tested. A consequence of that larger path to be travelled is that the excitation body 50 reaches a small egg later, and at a greater speed, than when a large egg is being tested.

[0045] For realizing measuring signals that are reproducible and can effectively be compared with each other, it is desired that the excitation body 50 reaches each egg at approximately the same speed, while touching the egg approximately according to a center line. For that purpose, in accordance with a further aspect of the present invention, an egg-testing device 1 is preferably individually controlled by a control device 200 which receives information about the diameter of an egg to be examined, and which performs the excitation of the bobbin 14 of that egg-testing device 1 on the basis of this information while taking into account the speed of a conveyor for the eggs, as will be explained hereinbelow with reference to Figs. 3 and 4.

[0046] Fig. 4 diagrammatically shows a side elevation of a testing apparatus 100 with a conveyor 110 for conveying eggs 3 to be examined along an egg-testing device 1 mounted on a subframe of the apparatus 100. Usually, the conveyor 110 is generally a roller conveyor known per se, such as is also described in EP-A-0.602.285. As the nature and construction of the roller conveyor do not constitute a subject of the present invention, and a skilled person need not have knowledge thereof for a proper understanding of the present invention, they will not be further described. It suffices to observe that the eggs 3 are conveyed along the egg-testing device 1 at a predetermined linear speed v , and also

rotate at a predetermined angular speed ω about their body axes or center lines 4, which are horizontally directed, perpendicularly to the conveying direction. Fig. 3 is a view in the longitudinal direction of the conveyor 110. Hourglass-like supports 112 mounted on bars 111 carry the eggs 3. Fig. 3 clearly shows that several egg-testing devices 1A, 1B and 1C can be juxtaposed for simultaneously testing one and the same egg 3 independently of one another.

[0047] Arranged upstream of the egg-testing device 1 is a diameter-measuring device 120. This measuring device 120 is adapted to generate at its output 121 a signal indicative of the diameter of a passing egg 3. That output 121 is connected to a signal input 201 of the control device 200, an excitation output 202 of which is connected to the wire ends 15, 16 of the bobbin 14.

[0048] A skilled person will understand that for the diameter-measuring device 120, any measuring device known per se and suitable for that purpose can be employed. By way of example, reference is here made to an infrared or ultrasonic distance detector, detecting the distance between that detector and a passing egg. As an alternative example, reference is here made to a combination of a light source disposed next to the conveyor and a column of light detectors which is disposed opposite thereto, on the other side of the conveyor, with a passing egg "obscuring" the lowermost light detectors, so that the diameter of that egg determines which light detectors will be obscured and which detectors will continue to receive light. As the nature and construction of the diameter-measuring device do not constitute a subject of the present invention, and a skilled person need not have knowledge thereof for a proper understanding of the present invention, they will not be further described.

[0049] The control device 200 is adapted to calculate an amplitude for the excitation current pulse (voltage pulse) for the bobbin 14 of the egg-testing device 1, starting from the signals received from the diameter-measuring device 120. As is already observed hereinabove, this pulse should be great enough to overcome the attractive force between the annular magnet 34 and the tube 11. If the pulse is precisely sufficiently great to overcome this attractive force, the probe 30 falls down at an initial speed $v_0 = 0$. However, if the pulse has a greater value, extra energy is transferred to the falling probe 30, in the form of kinetic energy, which is equivalent to an initial speed $v_0 > 0$.

[0050] It is known that a freely falling body is at least approximately controlled by the following formulae:

$$v(t) = v_0 + g \cdot t \quad (1)$$

$$s(t) = v_0 \cdot t + \frac{1}{2} g t^2 \quad (2)$$

wherein

t is the time of fall,

g is the acceleration caused by gravity,

v(t) is the time of fall at time t, and

s(t) is the path travelled at time t.

[0051] Hereinbelow, the time passing until the excitation member 50 of the probe 30 contacts the eggshell of an egg 3 will be designated by t_c , and the path to be travelled by the probe 30 from the rest position to the eggshell will be designated by $s(t_c)$. The speed at which the excitation member 50 collides with the eggshell will be designated by $v(t_c)$.

[0052] For a smaller egg, $s(t_c)$ is greater than for a larger egg. If the probe 30 were in each case excited with the same amplitude, the initial speed v_0 would always be the same. From formula (2) it then follows that for a smaller egg t_c is greater than for a larger egg, and from formula (1) it then follows that $v(t_c)$ is greater.

[0053] In accordance with the invention, the control device 200 is preferably adapted to calculate the amplitude and/or length of the excitation pulse on the basis of the diameter of the egg 3 in question, i.e. on the basis of $s(t_c)$, in such a manner that the initial speed v_0 has a magnitude such that $v(t_c)$ is for all eggs substantially equal to a predetermined target value v_c .

[0054] From the above, it will be understood that the amplitude for the excitation pulse is greater according as the diameter of the egg in question is larger.

[0055] The control device 200 is preferably adapted to calculate, starting from the signals received from the diameter-measuring device 120 and taking into account the speed v of the conveyor 110, when the egg 3 in question will precisely be located under the egg-testing device 1, i.e. the point of time t1 when the center line 4 of the egg 3 in question intersects the center line 2 of the probe 30, and to excite the bobbin 14 of the egg-testing device 1 at the point of time t1-t_c.

[0056] In this connection, it is observed that the control device 200 preferably comprises an input 203 for receiving instructions, for instance via a keyboard 210. This permits attending personnel to give the control device 200 instructions about the desired force with which the excitation member 50 excites the eggs 3, i.e. instructions about v_c . In this manner, it is possible to optimally adapt the egg-testing device 1 to different types of eggs: for instance, eggs that are known to have weak, thin shells can be excited "gently".

[0057] The control device 200 is provided with a signal input 204 coupled to the microphone 40, enabling the control device 200 to detect the exact point of time of excitation. After the passage of a predetermined time after this excitation time, the control device 200 excites the bobbin 14 again, but now with a pulse of opposite polarity, to promptly return the probe 30 to the rest position. To enable checking whether the probe 30 actually reaches the rest position, a signal input 205 of the con-

trol device 200 is coupled to the proximity sensor 43. In a practical embodiment, the second pulse is generated directly after excitation: the entire system has such a slowness, inter alia because the magnetic field has to be built up in the bobbin 14, that it automatically involves waiting for the above-mentioned predetermined time.

[0058] The egg 3 is now tested at one location, and the testing procedure took about 100-120 ms.

[0059] In general, it is desired to test each egg 3 at several locations along its circumference, measured according to the direction of rotation ω . In practice, several egg-testing devices 1 are used for that purpose, which devices are arranged one behind the other in the conveying direction, the distance in between being chosen in relation to the conveying speed v and the rotational speed ω . When it is for instance desired to test the eggs 3 at four positions, spaced apart 90° , four egg-testing devices 1, disposed one behind the other, are needed therefor.

[0060] In accordance with a further aspect of the present invention, each egg 3 is tested several times in succession by means of each egg-testing device 1. To that end, after the lapse of a predetermined wait time t_w after the abovedescribed testing procedure has ended, preferably about 30 ms, the bobbin 14 is re-excited with the first polarity, as a result of which the above testing procedure repeats itself. In the meantime, the egg 3 on the roller conveyor 110 has rotated through an angle α which is determined by, on the one hand, the rotational speed ω and, on the other, the duration t_p of the above-described testing procedure, increased by the above predetermined time t_w , according to the formula

$$\alpha = \omega \cdot (t_p + t_w).$$

[0061] Meanwhile, the egg 3 has also been displaced by the conveyor 110 through a horizontal distance A determined by, on the one hand, the conveying speed v and, on the other, the duration t_p of the above-described testing procedure, increased by the above predetermined time t_w , according to the formula $A = v \cdot (t_p + t_w)$. In order to ensure that the egg 3 is struck by the excitation member 50 at a central position all the same, i.e. substantially perpendicularly to the surface of the egg-shell, the egg-testing apparatus 100 according to the invention preferably has a subframe 101 which moves along with the conveyor 110. It is possible that the subframe 101 is displaced relative to a main frame, not shown, at a speed equal to the conveying speed v and, after two or more excitations, is placed back linearly, preferably at greater speed. However, it is also possible that the subframe 101 can pivot relative to the main frame about a horizontal axis which is perpendicular to the conveying direction, and which preferably intersects the center line 2 of the probe 30. Accordingly, the egg-testing device 1 makes a reciprocating swinging movement about that pivot.

[0062] Fig. 5A is illustrative of the signal provided by the microphone 40 during the testing of a "good" egg, while Fig. 5B is illustrative of the signal provided by the microphone 40 during the testing of a "bad" egg, such as a cracked egg. Plotted along the horizontal axis is the time; the length of the time axis shown corresponds to about 25 ms. Plotted along the vertical axis in arbitrary units is the intensity I of the measuring signal. The measuring signal can be characterized as a sinusoidal signal of decreasing amplitude. The maximum amplitude corresponds to a "collision" between the egg and the excitation member 50. In the illustration of Fig. 5A, four successive ones of such "collisions" can be recognized.

[0063] In the case of a cracked egg, the measuring signal can be characterized as a sinusoidal signal of a very rapidly decreasing amplitude, usually more rapidly than in the case of a good egg. Further, the number of times that the maximum amplitude occurs will be less: in the illustration of Fig. 5B, the maximum amplitude occurs only once.

[0064] In accordance with the invention, the measuring signal is examined in two manners. In the first place, the measuring signal is compared with a predetermined threshold value I_D . That threshold value I_D may be settable, and inputted by attending personnel. It is possible that the absolute value of the measuring signal is compared with the threshold value I_D .

[0065] Then, it is counted how often the measuring signal exceeds the threshold value I_D . In the illustration of Fig. 5A, this is 8 times. In a practical experiment, the measuring signal had a higher frequency than is sketched, and the counting value N for a good egg had a value in the range of from 10 to 20. In the case of a cracked egg, the counting value N is much lower: in the illustration of Fig. 5B, this is 1 time, but in practice, the counting value may still increase to about 5. In accordance with an aspect of the present invention, the counting value N is therefore compared with a predetermined threshold value N_{min} . If the condition $N > N_{min}$ is met, then the egg is approved by the testing apparatus 100. The threshold value N_{min} mentioned can likewise be settable and inputted by attending personnel.

[0066] However, in practice, it has appeared that situations may occur in which a good egg provides a measuring signal whose amplitude decreases very rapidly, as is sketched in Fig. 5B for a cracked egg, but for which the maximum amplitude nevertheless occurs just as often as in the case of a "normal" egg, i.e. four times in the example of Fig. 5A. In such a case, the counting value N can for instance be equal to 4, as a consequence of which the egg in question will be disapproved wrongly, on the basis of the above-mentioned criterion.

[0067] In accordance with a further aspect of the present invention, a solution to this problem is provided in that it is also monitored at which point of time (calculated from the first peak, or calculated from the excitation pulse of the first polarity provided by the control device 200) the measuring signal exceeds the threshold value

I_D , and the time t_L associated with the last time that this happens is compared with a predetermined threshold value t_{min} . If the condition $t_L > t_{min}$ is met, then the egg is approved by the testing apparatus 100. The threshold value t_{min} can also be settable and inputted by attending personnel. In the illustration of Fig. 5A, t_L is about 20 ms; a suitable value for t_{min} is, for instance, 15 ms.

[0068] In this manner, according to this aspect of the present invention, eggs are prevented from being disapproved wrongly. In fact, the latter method for judging the measuring signals is in itself sufficient for distinguishing good eggs from cracked eggs; with the former method it is also possible to make an observation about the size of a crack, if any.

[0069] In this connection, it is noted that it is not necessary to actually express the time in ms. It is sufficient to use a quantity representative of that time: for this purpose, clock pulses can for instance be counted. In an illustrative embodiment, by the excitation pulse provided by the control device 200, a counter controlled by a clock generator is also reset, and each time when the measuring signal exceeds the threshold value I_D , the counter reading is copied in a memory register. Accordingly, when the control device 200 generates the second excitation pulse in order to return the probe 30 to its rest position, to indicate that the measurement is over, the memory register can be read out.

[0070] It will be understood by a skilled person that it is possible to change or modify the embodiment shown of the device according to the invention, without departing from the scope as defined in the claims. For instance, it is possible that the excitation member 50 is magnetic, and that the tube 11 is magnetic. It is also possible that the annular magnet 34 is replaced by a number of magnetic bars, disposed along the circumference of the probe tube 31, adjacent the bottom end 32 thereof. Also, the choice of the materials used is not critical, as long as they are resistant to egg contents and the like without rusting.

[0071] Further, the examination of the measuring signal can be carried out by the control device 200 or by a separate signal-processing device.

Claims

1. 1. A probe (30) for testing an egg, comprising:

a hollow, tubular probe body (31);
an excitation body (50) disposed adjacent a first end (32) of the probe body (31); and
retaining means for retaining the excitation body (50) relative to the probe body (31), in such a manner that the excitation body (50) is free to carry out a vibrating movement in a direction parallel to a center line (2) of the probe body (31);

characterized in that:

the retaining means comprising means for generating a magnetic field for magnetically retaining the excitation body (50).

2. A probe according to claim 1, wherein the excitation body (50) is contactlessly retained by the magnetic field.
3. A probe according to claim 1 or 2, wherein the retaining means comprise at least one permanent magnet (34).
4. A probe according to claim 3, wherein the retaining means comprise a ring magnet (34) disposed adjacent the first end (32) of the probe body (31), and wherein the excitation body (50) is manufactured from a magnetically attractable material, preferably ferromagnetic stainless steel or nickel-plated steel.
5. A probe according to claim 4, wherein the excitation body (50) is spherical body.
6. An egg-testing device (1), comprising:
 - a probe (30) according to any one of the preceding claims;
 - a microphone (40) adapted to receive sound waves generated by the excitation body (50) in an air column (20) within the probe tube (31); and
 - a housing (10) wherein the probe (30) is bearing-mounted so as to be axially displaceable; wherein the microphone (40) is fixedly mounted relative to said housing (10).
7. An egg-testing device according to claim 6, wherein the microphone (40) is attached to an end of an elongated hollow support (24) extending into the interior of the hollow probe tube (31).
8. An egg-testing device according to claim 7, wherein the elongated hollow support (24) is attached to a cap (21) which comprises means (22) for attachment to a subframe (101).
9. An egg-testing device according to one of claims 6-8, wherein the housing (10) comprises:
 - a hollow metal tube (11) for guiding the probe (30),
 - comprising a fastening flange (12) for attachment to a subframe (101), and comprising a bobbin (14) provided around said tube (11).
10. An egg-testing device according to one of claims 6-9, wherein on a second end (35) of the probe tube (31) a stop flange (36) is formed for defining a low-

est extreme position of the probe (30).

11. An egg-testing device according to claim 10, wherein the stop flange (36) is formed by a second annular magnet (36). 5
12. An egg-testing device according to any one of claims 6-11, comprising a sensor (43) for detecting the position of the probe (30) relative to the housing (10). 10
13. An egg-testing device according to claim 12, wherein the sensor (43) is a proximity sensor, preferably a Hall sensor. 15
14. A testing apparatus (100) for testing eggs, comprising at least one egg-testing device according to any one of claims 6-13, and having a diameter-measuring device (120) adapted to generate, at an output (121) thereof, a signal indicative of the diameter of an egg. 20
15. A testing apparatus according to claim 14, comprising a control device (200) of which a signal input (201) is connected to the output (121) of the diameter-measuring device (120), and of which an excitation output (202) is connected to the bobbin (14), said control device (200) being adapted to control each egg-testing device (1) individually on the basis of the signals received at its input (201). 25
30
16. A testing apparatus according to claim 15, wherein the control device (200) is adapted to set the amplitude and/or length of the excitation pulse for each bobbin (14) so that the excitation body (50) reaches each egg (3) at a speed which is substantially equal to a predetermined target value v_c . 35
17. A testing apparatus according to claim 15 or 16, comprising a conveyor (110) for conveying eggs (3) to be examined along the egg-testing devices (1), wherein the control device (200) is adapted to excite each bobbin (14) on the basis of the diameter of the eggs (3) to be examined and taking into account the speed (v) of the conveyor (110). 40
45
18. A testing apparatus according to any one of claims 15-17, wherein the control device (200) is adapted to set the timing of the excitation pulse for each bobbin (14) so that the excitation body (50) strikes each egg (3) when the center line (4) of said egg (3) substantially intersects the center line (2) of the probe (30). 50
19. A testing apparatus according to any one of claims 15-18, wherein the control device (200) is adapted to re-excite each bobbin (14) after a predetermined wait time (t_w) in order to test an egg (3) at least twice 55

by means of the same egg-testing device (1).

20. A testing apparatus according to claim 19, wherein a subframe (101) is provided which moves along with the conveyor (110) and to which the egg-testing devices (1) are attached.
21. A testing apparatus according to claim 20, wherein the subframe (101) is able to pivot about a horizontal axis perpendicular to the conveying direction.
22. A method for examining an egg (3) for the presence of ruptures and/or cracks, wherein a measuring signal is provided by means of a probe (30) according to one of claims 1-5, wherein the measuring signal is compared with a predetermined threshold value (I_D), wherein it is counted how often the measuring signal exceeds the threshold value (I_D), wherein the count value (N) is compared with a predetermined threshold value (N_{min}), and wherein the egg is approved if the condition $N > N_{min}$ is met.
23. A method for examining an egg (3) for the presence of ruptures and/or cracks, wherein a measuring signal is provided by means of a probe (30) according to one of claims 1-5, wherein the measuring signal is compared with a predetermined threshold value (I_D), wherein a point of time, (t_L) associated with the last time that the measuring signal exceeds said threshold value I_D , is compared with a predetermined threshold value (t_{min}), and wherein the egg is approved if the condition $t_L > t_{min}$ is met.

Patentansprüche

1. Sonde (30) zum Testen eines Eis, mit:

einem hohlen, röhrenförmigen Sondenkörper (31);

einem Erregerkörper (50), der an einem ersten Ende (32) des Sondenkörpers (31) angeordnet ist; und

einer Rückhaltevorrichtung zum Rückhalten des Erregerkörpers (50) relativ zu dem Sondenkörper (31) derart, dass der Erregerkörper (50) frei ist, um eine Vibrationsbewegung in einer parallel zu einer Mittellinie (2) des Sondenkörpers (31) verlaufenden Richtung auszuführen;

dadurch gekennzeichnet, dass:

die Rückhaltevorrichtung eine Vorrichtung zum Erzeugen eines Magnetfelds aufweist, um den Erregerkörper (50) magnetisch rückzuhalten.

2. Sonde nach Anspruch 1, bei der der Erregerkörper (50) durch das Magnetfeld berührungslos rückgehalten wird. 5
3. Sonde nach Anspruch 1 oder 2 bei der die Rückhaltevorrichtung mindestens einen Dauermagneten (34) aufweist. 10
4. Sonde nach Anspruch 3, bei der die Rückhaltevorrichtung einen an dem ersten Ende (32) des Sondenkörpers (31) angeordneten Ringmagneten (34) aufweist, und bei der der Erregerkörper (50) aus einem magnetisch anziehbaren Material besteht, vorzugsweise aus ferromagnetischem Edelstahl oder nickelplattiertem Stahl. 15
5. Sonde nach Anspruch 4, bei der der Erregerkörper (50) ein sphärischer Körper ist. 20
6. Eiertestvorrichtung (1) mit:
 - einer Sonde (30) nach einem der vorhergehenden Ansprüche; 25
 - einem Mikrophon (40), das zum Empfang von Tonwellen geeignet ist, die von dem Erregerkörper (50) in einer innerhalb der Sondenröhre (31) befindlichen Luftsäule (20) erzeugt werden; und 30
 - einem Gehäuse (10), in dem die Sonde (30) axial verschiebbar gelagert ist; 35
 - wobei das Mikrophon (40) relativ zu dem Gehäuse (10) fest montiert ist. 40
7. Eiertestvorrichtung nach Anspruch 6, bei der das Mikrophon (40) an einem Ende eines länglichen hohlen Trägers (24) befestigt ist, das in das Innere der hohlen Sondenröhre (31) ragt. 45
8. Eiertestvorrichtung nach Anspruch 7, bei der der längliche hohle Träger (24) an einer Kappe (21) befestigt ist, die mit einer Befestigungseinrichtung (22) an einem Unterrahmen (101) versehen ist. 50
9. Eiertestvorrichtung nach einem der Ansprüche 6-8, bei der das Gehäuse (10) aufweist:
 - eine zum Führen der Sonde (30) vorgesehene hohle Metallröhre (11), die einen Befestigungsflansch (12) zur Befestigung an einem Unterrahmen (101) und eine um die Röhre (11) herum angeordnete Spule (14) aufweist. 55
10. Eiertestvorrichtung nach einem der Ansprüche 6-9, bei der an einem zweiten Ende (35) der Sondenröhre (31) ein Stoppflansch (36) ausgebildet ist, um die äußerste untere Position der Sonde (30) zu definieren. 60
11. Eiertestvorrichtung nach Anspruch 10, bei der der Stoppflansch (36) durch einen zweiten Ringmagneten (36) gebildet ist. 65
12. Eiertestvorrichtung nach einem der Ansprüche 6-11, mit einem Sensor (43) zum Detektieren der Position der Sonde (30) relativ zu dem Gehäuse (10). 70
13. Eiertestvorrichtung nach Anspruch 12, bei der der Sensor (43) ein Näherungssensor, vorzugsweise ein Hall-Sensor ist. 75
14. Testvorrichtung (100) zum Testen von Eiern, mit mindestens einer Eiertestvorrichtung nach einem der Ansprüche 6-13 und mit einer Durchmesser-Messvorrichtung (120), die in der Lage ist, an einem Ausgang (121) ein den Durchmesser eines Eis angegebendes Signal zu erzeugen. 80
15. Testvorrichtung nach Anspruch 14, mit einer Steuervorrichtung (200), die über einen Signaleingang (201) mit dem Ausgang (121) der Durchmesser-Messvorrichtung (120) verbunden ist, und die über einen Erreger-Ausgang (202) mit der Spule (14) verbunden ist, wobei die Steuervorrichtung (200) in der Lage ist, auf der Basis der an ihrem Eingang (201) empfangenen Signale jede Eiertestvorrichtung (1) einzeln zu steuern. 85
16. Testvorrichtung nach Anspruch 15, bei der die Steuervorrichtung (200) in der Lage ist, die Amplitude und/oder die Länge des Erregerimpulses für jede Spule (14) derart einzustellen, dass der Erregerkörper (50) ein Ei (3) mit einer Geschwindigkeit erreicht, die im wesentlichen gleich einem vorbestimmten Zielwert V_c ist. 90
17. Testvorrichtung nach Anspruch 15 oder 16, mit einem Förderer (110), um zu testende Eier (3) entlang der Eiertestvorrichtungen (1) zu fördern, wobei die Steuervorrichtung (200) in der Lage ist, jede Spule (14) auf der Basis des Durchmessers der zu prüfenden Eier (3) zu erregen und dabei die Geschwindigkeit (v) des Förderers (110) zu berücksichtigen. 95
18. Testvorrichtung nach einem der Ansprüche 15-17, bei der die Steuervorrichtung (200) in der Lage ist, die Zeitgebung des Erregerimpulses für jede Spule (14) derart einzustellen, dass der Erregerkörper (50) auf jedes Ei (3) auftrifft, wenn die Mittellinie (4) des Eis (3) die Mittellinie (2) der Sonde (30) im wesentlichen schneidet. 100
19. Testvorrichtung nach einem der Ansprüche 15-18, bei der die Steuervorrichtung (200) in der Lage ist, 105

- jede Spule (14) nach einer vorbestimmten Wartezeit (t_w) neu zu erregen, um ein Ei (3) mindestens zweifach mittels derselben Eiertestvorrichtung (1) zu testen.
20. Testvorrichtung nach Anspruch 19, bei der ein Unterraum (101) vorgesehen ist, der sich zusammen mit dem Förderer (110) bewegt und an dem die Eiertestvorrichtungen (1) befestigt sind.
21. Testvorrichtung nach Anspruch 19, bei der der Unterraum (101) um eine rechtwinklig zur Förderrichtung verlaufende horizontale Achse drehbar ist.
22. Verfahren zum Prüfen eines Eis (3) auf das Vorhandensein von Brüchen und/oder Rissen, bei dem ein Messsignal mittels einer Sonde (30) nach einem der Ansprüche 1-5 erzeugt wird, das Messsignal mit einem vorbestimmten Schwellwert (I_D) verglichen wird, eine Zählung der Häufigkeit vorgenommen wird, mit der das Messsignal den Schwellwert (I_D) überschreitet, der Zählwert (N) mit einem vorbestimmten Schwellwert (N_{min}) verglichen wird, und das Ei für gut befunden wird, falls die Bedingung $N > N_{min}$ erfüllt wird.
23. Verfahren zum Prüfen eines Eis (3) auf das Vorhandensein von Brüchen und/oder Rissen, bei dem ein Messsignal mittels einer Sonde (30) nach einem der Ansprüche 1-5 erzeugt wird, das Messsignal mit einem vorbestimmten Schwellwert (I_D) verglichen wird, wobei ein Zeitpunkt (t_L) des letzten Mals, an dem das Messsignal den Schwellwert (I_D) überschreitet, mit einem vorbestimmten Schwellwert (t_{min}) verglichen wird, und das Ei für gut befunden wird, falls die Bedingung $t_L > T_{min}$ erfüllt wird.

Revendications

1. Sonde (30) pour tester un oeuf, comprenant :

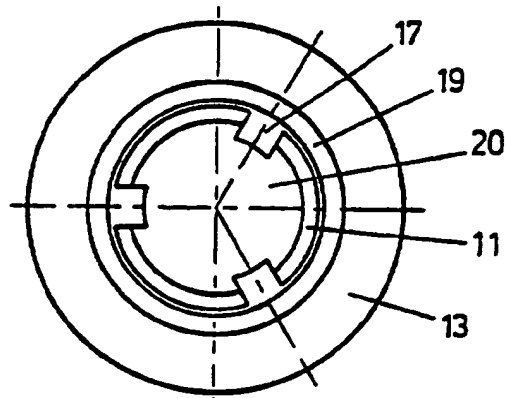
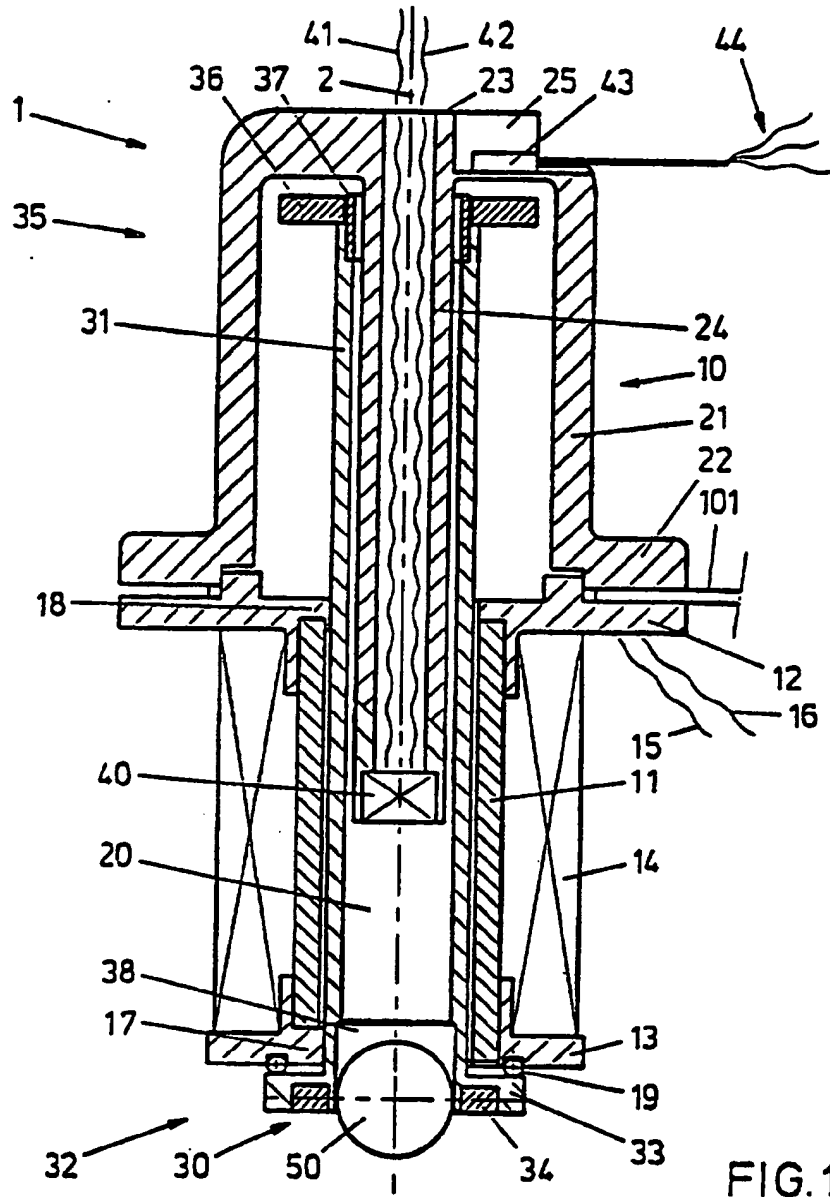
un corps creux (31) de sonde tubulaire,
un corps d'excitation (50) disposé près d'une première extrémité (32) du corps de sonde (31), et
un dispositif de retenue du corps d'excitation (50) par rapport au corps de sonde (31) de manière que le corps d'excitation (50) soit libre d'effectuer un mouvement de vibration en direction parallèle à un axe central (2) du corps de sonde (31),

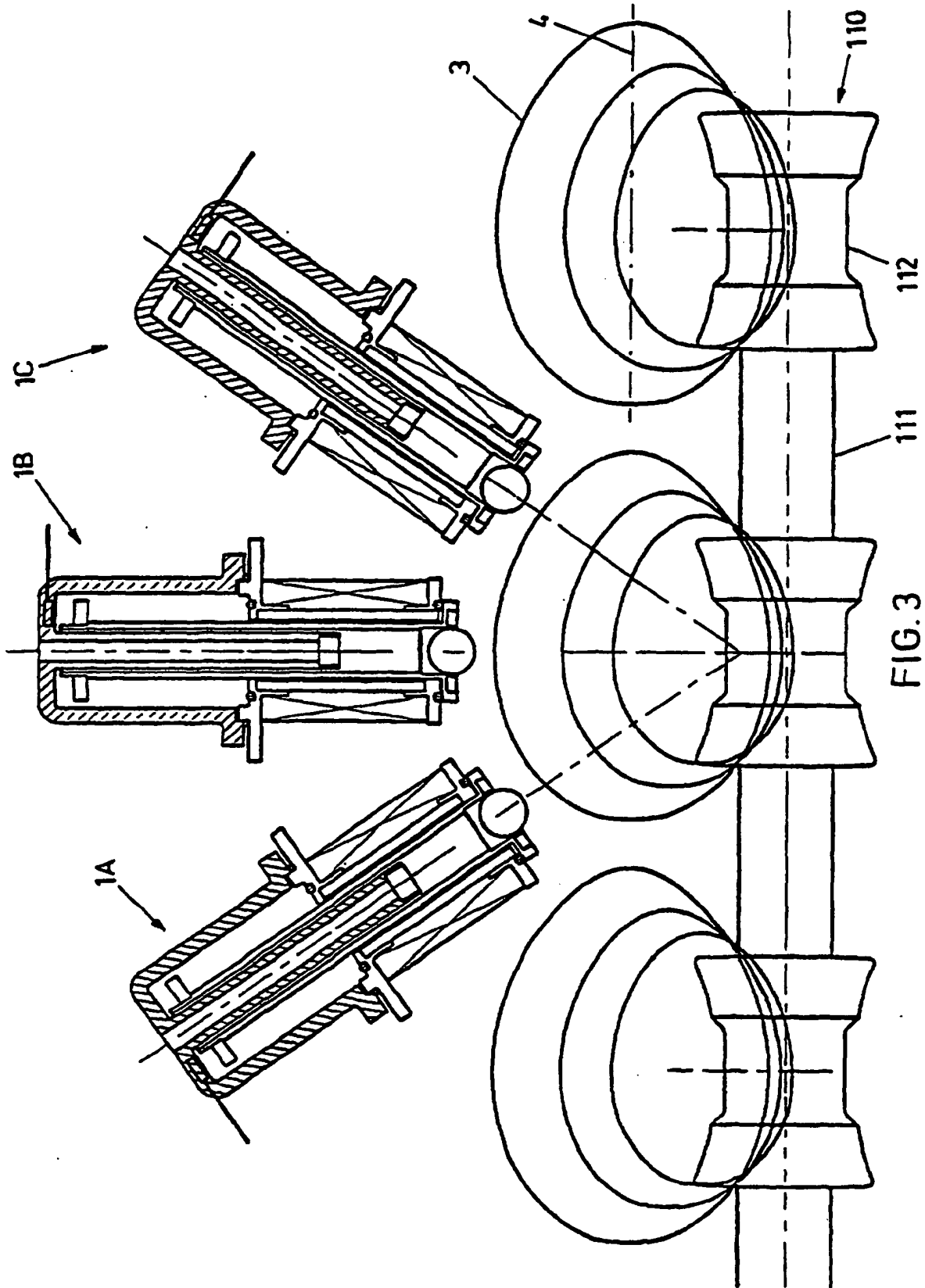
caractérisé en ce qu

le dispositif de retenue comprend un dispositif générateur d'un champ magnétique destiné à retenir magnétiquement le corps d'excitation (50).

2. Sonde selon la revendication 1, dans laquelle le corps d'excitation (50) est retenu par le champ magnétique sans contact.
3. Sonde selon la revendication 1 ou 2, dans laquelle le dispositif de retenue comporte au moins un aimant permanent (34).
4. Sonde selon la revendication 3, dans laquelle le dispositif de retenue comporte un aimant annulaire (34) disposé près de la première extrémité (32) du corps de sonde (31), et dans lequel le corps d'excitation (50) est réalisé en un matériau qui peut être attiré magnétiquement, de préférence de l'acier inoxydable ferromagnétique ou de l'acier nickelé.
5. Sonde selon la revendication 4, dans laquelle le corps d'excitation (50) est un corps sphérique.
6. Appareil pour tester les oeufs (1), comprenant :
- une sonde (30) selon l'une quelconque des revendications précédentes,
un microphone (40) destiné à recevoir des ondes acoustiques créées par le corps d'excitation (50) dans une colonne d'air (20) à l'intérieur du tube de sonde (31), et
un boîtier (10) dans lequel la sonde (30) est montée par un palier afin qu'elle puisse être déplacée axialement,
dans lequel le microphone (40) est monté de manière fixe par rapport au boîtier (10).
7. Appareil pour tester les oeufs selon la revendication 6, dans lequel le microphone (40) est fixé à une extrémité d'un support creux allongé (24) qui s'étend à l'intérieur du tube de sonde (31).
8. Appareil pour tester les oeufs selon la revendication 7, dans lequel le support creux allongé (24) est fixé à un capuchon (21) qui comporte un dispositif (22) de fixation à un châssis auxiliaire (101).
9. Appareil pour tester les oeufs selon l'une des revendications 6 à 8, dans lequel le boîtier (10) comprend :
- un tube métallique (11) de guidage de la sonde (30), comprenant un flasque (12) de fixation à un châssis auxiliaire (101) et comprenant une bobine (14) disposée autour du tube (11).
10. Appareil pour tester les oeufs selon l'une des revendications 6 à 9, dans lequel à une seconde extrémité (35) du tube de sonde (31) est formé un flasque d'arrêt (36) destiné à délimiter une position la plus basse de la sonde (30).
11. Appareil pour tester les oeufs selon la revendication

- 10, dans lequel le flasque d'arrêt (36) est formé par un second aimant annulaire (36).
12. Appareil pour tester les oeufs selon l'une quelconque des revendications 6 à 11, comprenant un capteur (43) de détection de la position de la sonde (30) par rapport au boîtier (10).
13. Appareil pour tester les oeufs selon la revendication 12, dans lequel le capteur (43) est un capteur de proximité, de préférence un capteur à effet Hall.
14. Appareillage de test (100) destiné à tester les oeufs, comprenant au moins un appareil à tester les oeufs selon l'une quelconque des revendications 6 à 13, et ayant un appareil (120) de mesure de diamètre destiné à créer, à une sortie (121), un signal représentatif du diamètre d'un oeuf.
15. Appareillage de test selon la revendication 14, comprenant un appareil de commande (200) dont une entrée de signal (201) est connectée à la sortie (121) de l'appareil de mesure de diamètre (120), et dont une sortie d'excitation (202) est connectée à la bobine (14), l'appareil de commande (200) étant destiné à commander chaque appareil pour tester les oeufs (1) individuellement en fonction des signaux reçus à son entrée (201).
16. Appareillage de test selon la revendication 15, dans lequel l'appareil de commande (200) est destiné à régler l'amplitude et/ou la longueur de l'impulsion d'excitation pour chaque bobine (14) afin que le corps d'excitation (50) atteigne chaque oeuf (3) à une vitesse pratiquement égale à une valeur cible prédéterminée v_c .
17. Appareillage de test selon la revendication 15 ou 16, comprenant un transporteur (110) destiné à transporter des oeufs (3) à examiner le long des appareils à tester les oeufs (1), dans lequel l'appareil de commande (200) est destiné à exciter chaque bobine (14) d'après le diamètre des oeufs (3) à examiner et avec prise en compte de la vitesse (v) du transporteur (110).
18. Appareillage de test selon l'une quelconque des revendications 15 à 17, dans lequel l'appareil de commande (200) est destiné à régler la durée de l'impulsion de l'excitation pour chaque bobine (14) afin que le corps d'excitation (50) frappe chaque oeuf (3) lorsque l'axe central (4) de l'oeuf (3) recoupe pratiquement l'axe central (2) de la sonde (30).
19. Appareillage de test selon l'une quelconque des revendications 15 à 18, dans lequel l'appareil de commande (200) est destiné à exciter à nouveau chaque bobine (14) après un temps prédéterminé d'attente (t_w) afin de tester un oeuf (3) au moins deux fois à l'aide du même appareil pour tester les oeufs (1).
20. Appareillage de test selon la revendication 19, dans lequel un châssis auxiliaire (101) est incorporé et se déplace avec le transporteur (110) et les appareils pour tester les oeufs (1) lui sont fixés.
21. Appareillage de test selon la revendication 20, dans lequel le châssis auxiliaire (101) peut pivoter autour d'un axe horizontal perpendiculaire à la direction de transport.
22. Procédé d'examen d'un oeuf (3) pour la détermination de la présence de ruptures et/ou de fissures, dans lequel un signal de mesure est transmis par une sonde (30) selon l'une des revendications 1 à 5, dans lequel le signal de mesure est comparé à une valeur prédéterminée de seuil (I_D), dans lequel le nombre de fois où le signal de mesure dépasse la valeur de seuil (I_D) est compté, dans lequel la valeur comptée (N) est comparée à une valeur prédéterminée de seuil (N_{min}), et dans lequel l'oeuf est approuvé lorsque la condition suivante est remplie : $N > N_{min}$.
23. Procédé d'examen d'un oeuf (3) pour la détermination de la présence de ruptures et/ou fissures, dans lequel un signal de mesure est transmis par une sonde (30) selon l'une des revendications 1 à 5, dans lequel le signal de mesure est comparé à une valeur prédéterminée de seuil (I_D), dans lequel un moment (t_L) associé au dernier moment où le signal de mesure a dépassé une valeur de seuil (I_D) est comparé à une valeur prédéterminée de seuil (t_{min}), et dans lequel l'oeuf est approuvé lorsque la condition suivante est remplie $t_L > t_{min}$.





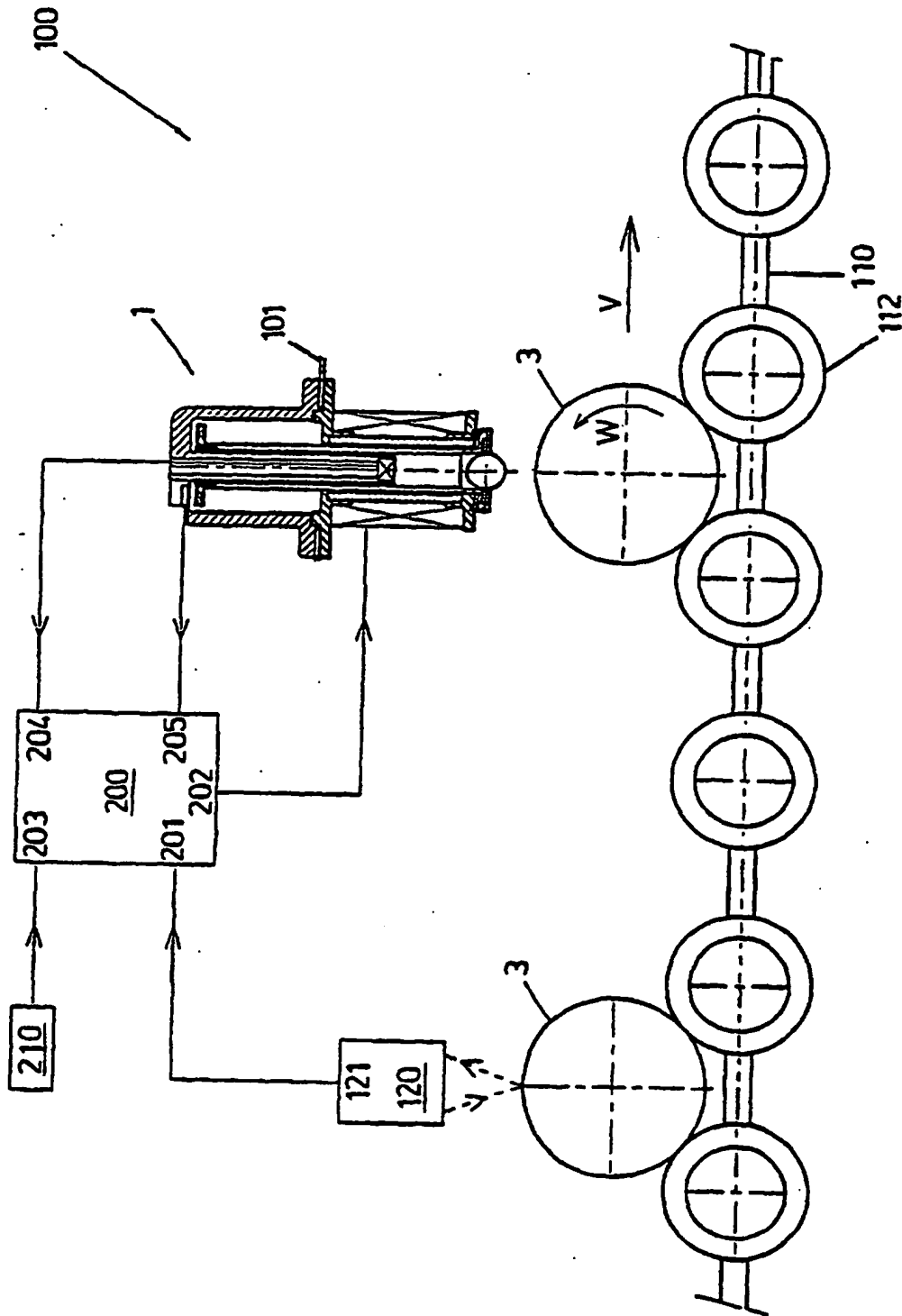


FIG.4

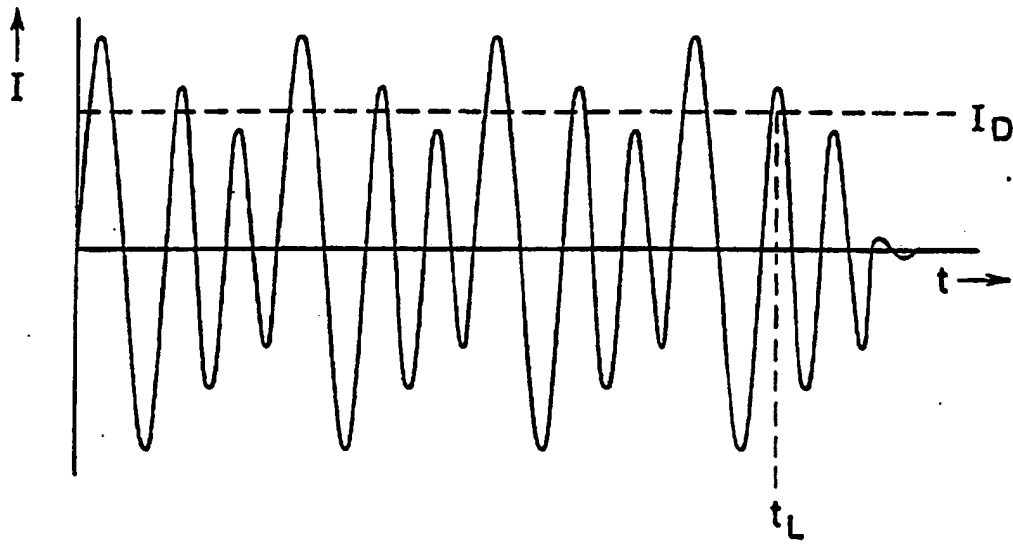


FIG. 5A

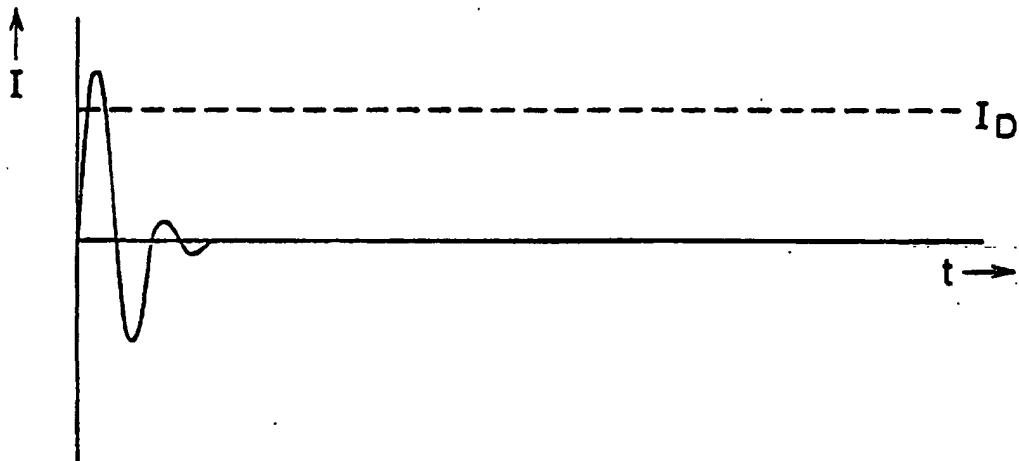


FIG. 5B